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SOLID ROCKET PLANT

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TWENTY-FIRST MONTHLY PROGRESS REPORT
ALGOL SOLID ROCKET MOTOR PROGRAM

Contract No. NAS 1-1330

Period Covered: February 1963

Report 0498-01M-21

March 1963

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AEROJET-GENERAL CORPORATION

SACRAMENTO, CALIFORNIA

March 1963

Report 0498-01M-21

TWENTY-FIRST MONTHLY PROGRESS REPORT

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Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
Langley Field, Virginia

AEROJET-GENERAL CORPORATION
A SUBSIDIARY OF THE GENERAL TIRE & RUBBER COMPANY

PREFACE

This report was prepared by M. C. Huisking, Engineering Project Assistant, and edited by Doris Hollister.

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1. INTRODUCTION

This is the twenty-first monthly progress report to the National Aeronautics and Space Administration (NASA) under Contract NAS 1-1330. This report covers the fabrication, testing, and delivery of Algol solid rocket motors for the Scout vehicle. The program has been redirected a number of times; a summary of the program history follows:

PROGRAM MILESTONES

Date	Event
June 1961	The Algol I phase of the program was established with the receipt of a letter of intent covering 17 Algol I motors: 16 delivery motors and one motor for static firing.
November 1961	Direction was received for the development of a new motor (designated Algol IIA) and the reduction of the number of motors in the existing Algol I phase.
January 1962	A contract amendment that reduced the number of Algol I motors to nine was received. The original Algol II phase consisted of the design, development, and testing of 14 Algol IIA motors: ten delivery motors and four motors for static firings; delivery of three Algol Dual Transporters; and tooling for processing four units per month.
February 1962	Contract negotiations on scope of work defined in January were completed.
April 1962	Contract Change Notice (CCN) 1 for the fabrication and delivery of two borescopes was received.
June 1962	A contract was negotiated for a follow-on order for the delivery of 13 additional Algol IIA motors.

I. Introduction (cont.)

November 1962	Direction to reduce the Algol IIA motor delivery rate from four to two units per month was received, extending the delivery schedule by 6 months.
December 1962	Authority to proceed with rehabilitating the Algol IIA-3 chamber for an additional (fifth) static test was received.
January 1963	Direction to conduct the proposed fifth static test with the Algol IIA-3 rehabilitated chamber was received.

The Algol I phase of the program was completed in May 1962 and descriptions of this past effort are no longer reported.

The schedule for the Algol IIA program (Figure 1) shows the reduction in the delivery rate of Algol IIA motors from four to two units per month in compliance with the direction received in November 1962. Also scheduled in accordance with the direction received in January, 1963, is the fifth firing, that of the rehabilitated IIA-3 motor, IIA-3 (Rehab). The firing is now scheduled for March 15.

II. SUMMARY

With the production schedule acceleration during January, the production effort is now back on schedule. Motors Algol IIA-3 (Rehab) and IIA-19 were cast during February. As requested by NASA, the scheduled Algol IIA-3 (Rehab) firing date of 25 February 1963 was rescheduled to 15 March 1963 to incorporate use of an igniter with an improved initiator seal.

Motor IIA-13 is ready to be radiographically inspected and delivered as soon as the nozzle is returned. Motors IIA-14, -15 and -17 were sent to

to Naval Ammunition Depot (NAD) Concord, Calif., for radiographic inspection. Inspection of IIA-14 and -15 has been completed. Motor IIA-16 will be sent to NAD the first week of March; IIA-18 is in final assembly.

Telemetry data received on flight-tested Algol motors IIA-4, -5 and -6 indicate excellent agreement between predicted and measured burning rates. This burning rate study is being conducted concurrently with the development program and, as the number of motors processed, fired and/or launched increases, will be useful for predicting Scout-vehicle performance.

III. PROGRAM STATUS

A. DESIGN

The basic development phase of the program was completed with the fourth static firing. The last two motors were of flight configuration, and data from these tests demonstrated the effectiveness of the design; consequently, the design of major components has been established. A final (fifth) motor will be fired to confirm motor ballistics, acceptability of the aluminum case, and qualification of a second-source nozzle from CTL, Santa Ana, Calif.

A comprehensive study of motor performance variations and predictability will be submitted as a separate report. Information compiled to date on variations in both motor hardware fabrication and propellant processing shows good correlation for the somewhat limited data available. Telemetry data received on the flight tests of Algol IIA-4, -5 and -6 show excellent agreement with both the predicted shape of the pressure and thrust curves and the predicted web burning times. Curves showing predicted and measured performance are presented in Figures 2 through 4. A tabulation of predicted and measured web burning times follows:

B. A. Design (cont.)

MOTOR	WEB BURNING TIME, SEC	
	PREDICTED	MEASURED
Algol IIA-4	43.0	43.0
Algol IIA-5	44.5	44.5
Algol IIA-6	45.6	46.0

Full-scale performance is now predicted by adding 0.005 to the burning rates obtained from batch-test motor firings and using the new burning rates in the computer program.

A NASA directive requires the use of an igniter with an improved initiator seal in the fifth static test. Because of the time required to change the igniter design, the fifth static test was rescheduled for 15 March 1963.

B. FABRICATION

The chambers for the follow-on order (13 motors) are being fabricated. The insulated chambers for Algol IIA-23 and -24 have been received, bringing the total insulated chambers received to eleven. Nozzles for the follow-on order are being fabricated; ten have been received to date, including three received in February.

C. MOTOR PROCESSING AND SHIPPING

1. Motor Processing

Processing of the Algol IIA motor was affected by a NASA directive, TWX 337-338, S. T. Butler to C. W. Parr--Subject: Radiographic Inspection--Dated 30 August 1962. This directive added to the contract the

III. C. Motor Processing and Shipping (cont.)

requirement that all deliverable motors be inspected with either a borescope or radiograph. Motors IIA-4 through -9 were processed with Styrofoam star points imbedded in the grain. These Styrofoam inserts were originally used to change the configuration of the temporary wood cores for a grain-design modification. Because adequate release agents are unavailable, these inserts are not released from the propellant but become an integral part of the motor. The presence of the Styrofoam in the bore of the grain physically obstructs the use of a borescope for inspecting the motor interior. After several attempts, the Styrofoam was mechanically removed from motors IIA-6 and -7. Motor IIA-7 was borescopically inspected in conjunction with the borescope training program conducted by Aerojet-General for NASA personnel.

Wood inserts were used in motors IIA-10, 11, -12, and -13 without any complications. An aluminum hard core was used in casting all subsequent motors. The following is a summary of the status of motors 13 through 19:

Motor	Status	Grain Status	Inspection Status
IIA-13	Nozzle to be installed	Wood insert, removed	To be radiographically inspected at NAD
IIA-14	Delivered	Aluminum hard core removed	Radiographically inspected at NAD
IIA-15	Delivered	Aluminum hard core removed	Radiographically inspected at NAD
IIA-16	To be delivered	Aluminum hard core removed	To be radiographically inspected at NAD
IIA-17	Delivered	Aluminum hard core removed	To be radiographically inspected at NAD
IIA-18	In final assembly	Aluminum hard core removed	To be radiographically inspected at NAD
IIA-19	Cast	Aluminum hard core	To be radiographically inspected at NAD

III. C. Motor Processing and Shipping (cont.)

2. Shipping

Algol IIA Government-furnished equipment (GFE) now in storage at Aerojet-General consists of the following:

Item	Serial No.
Dual transporter	ATT-2
Dual transporter	ATT-3
Transtainer(1)	T-13
Transtainer(1)	T-1
APU (temperature control)(1, 2)	109B621179/109B621181
APU (temperature control)(1, 2)	40C634807/40C634809
APU (temperature control)(1, 2)	40C634797/40C634810
APU (temperature control)(2)	40C634798/40C634812
APU (temperature control)(2)	70C639496/70C636879

(1) Reference Gwg 0-320359

(2) Does not include tie-down chain

E. TOOLING

The tooling schedule is shown in Figure 5. The third aluminum hard core was received and accepted following rework necessitated by the presence of surface irregularities and dimensional discrepancies. Tooling is now complete.

IV. FUTURE WORK

A. Processing of delivery motors will continue during March. Algol motors IIA-13, -16, -18, and -19 will be shipped to NAD, Concord, Calif.

IV. Future Work (cont.)

for radiographic inspection. After inspection, the units will be shipped to their final destinations.

B. Fabrication required for the follow-on order of 15 sets of inert parts will continue.

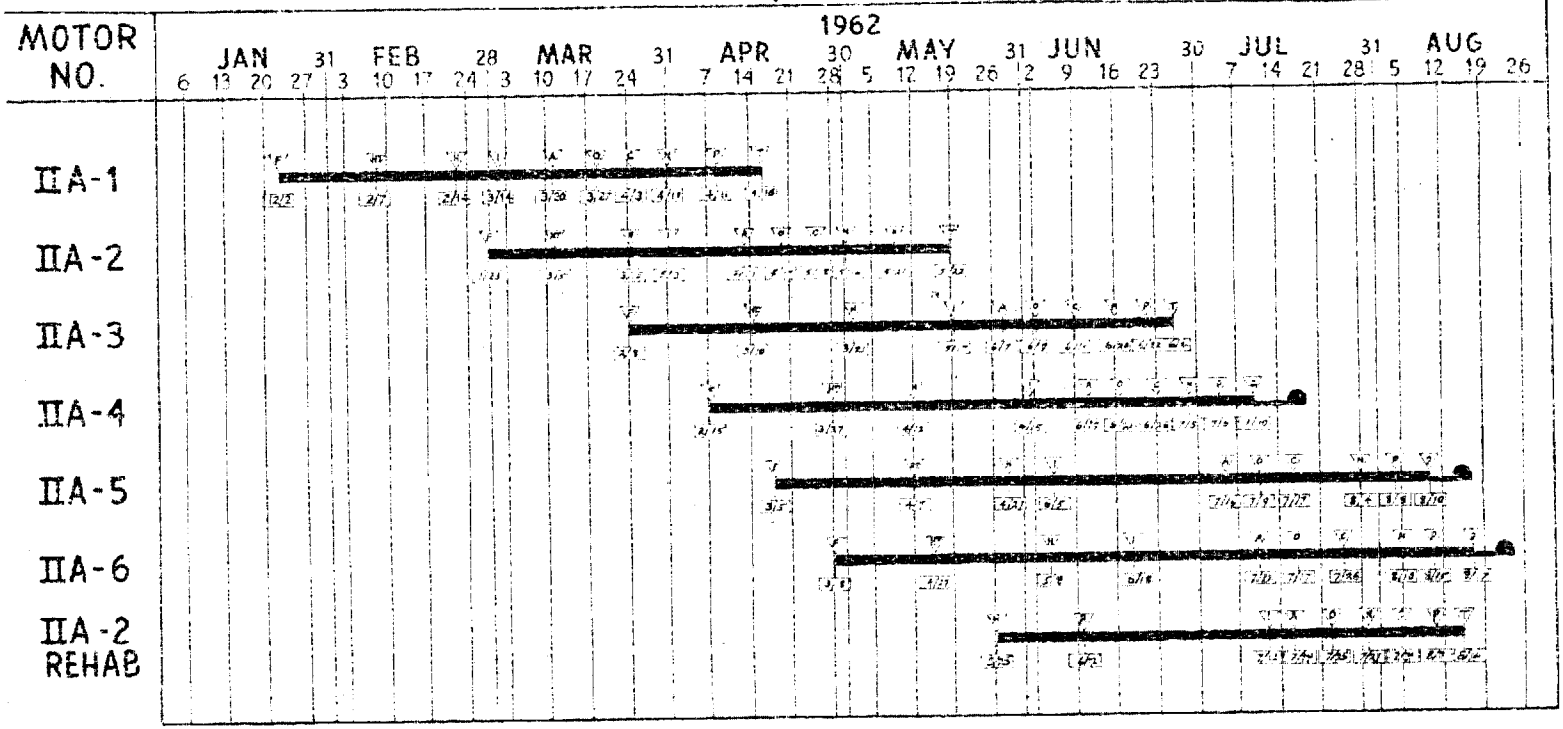
C. The refurbished Algol IIA-3 motor, designated IIA-3 (Rehab), is scheduled to be statically fired at ambient temperature on 15 March 1963. Following the firing, preliminary ballistic and thermal data, and data on jet-vane deflection, lift, drag, and hinge moment will be reduced and forwarded to NASA for review.

ALGOL II A

NAS-1-1330

MOTOR PRODUCTION/DELIVERY SCHEDULE

SCHEDULE REVISION "E" NOV 1962
LETTER CONTRACT RECEIVED 7 JUNE 1961

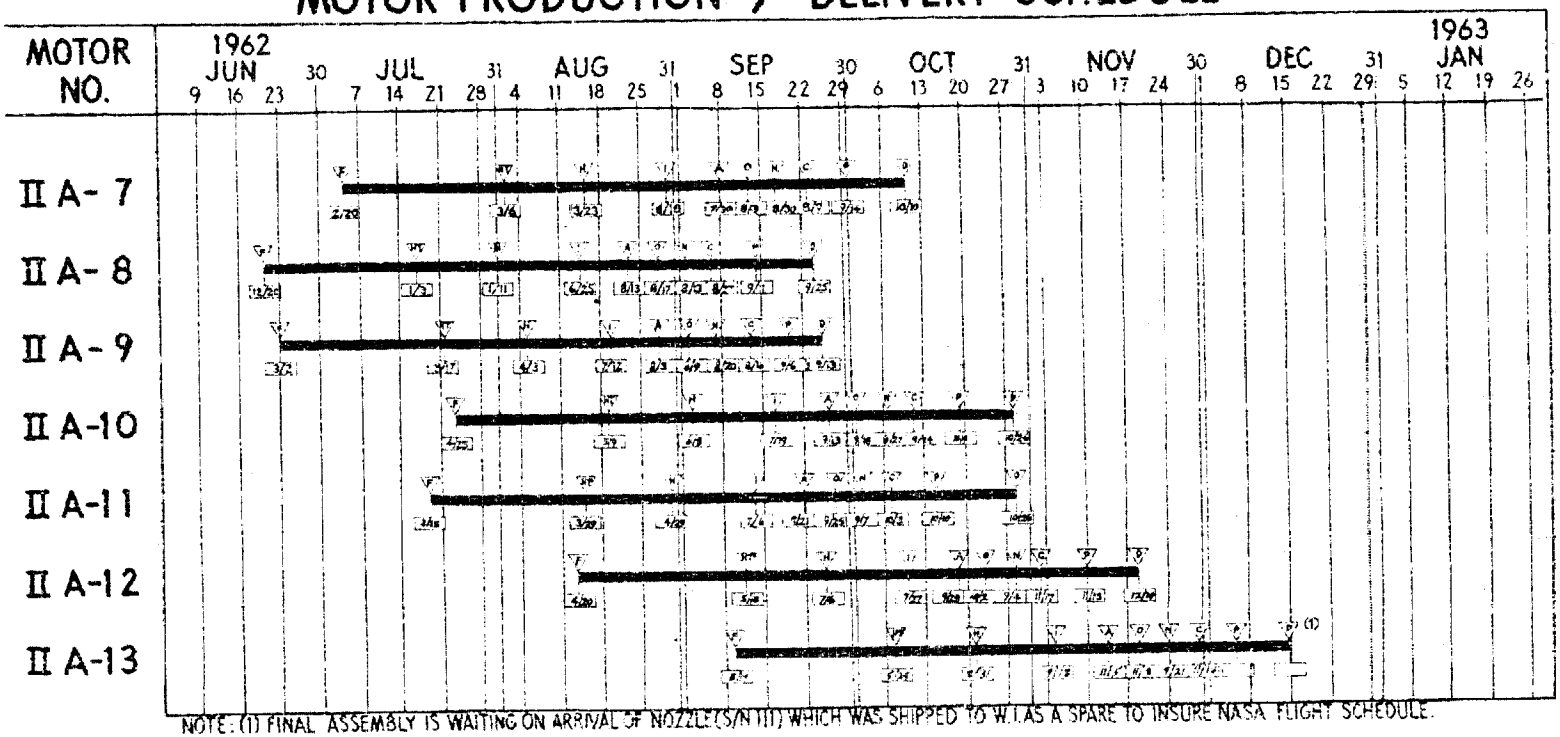


F START FABRICATION CHAMBER
HT HEAT TREAT
H HYDROTEST
R REHABILITATE CHAMBER
I INSULATE CHAMBER
A RECEIVE, ABRADE AND LINE
O CAST PROPELLANT
C CURE PROPELLANT
N RECEIVE NOZZLE
P FINAL ASSEMBLY
D FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
T TEST FIRE (A.G.C. SACRAMENTO)
▽ SCHEDULED TASK COMPLETION DATE
[DATE] ACTUAL DATE TASK COMPLETED
---- REVIEW DATE— ● FLOWN(SUCCESS)

TP 7415
4 JAN 63

ALGOL II A

MOTOR PRODUCTION / DELIVERY SCHEDULE



NOTE: (1) FINAL ASSEMBLY IS WAITING ON ARRIVAL OF NOZZLE(S/N 111) WHICH WAS SHIPPED TO W.I. AS A SPARE TO INSURE NASA FLIGHT SCHEDULE.

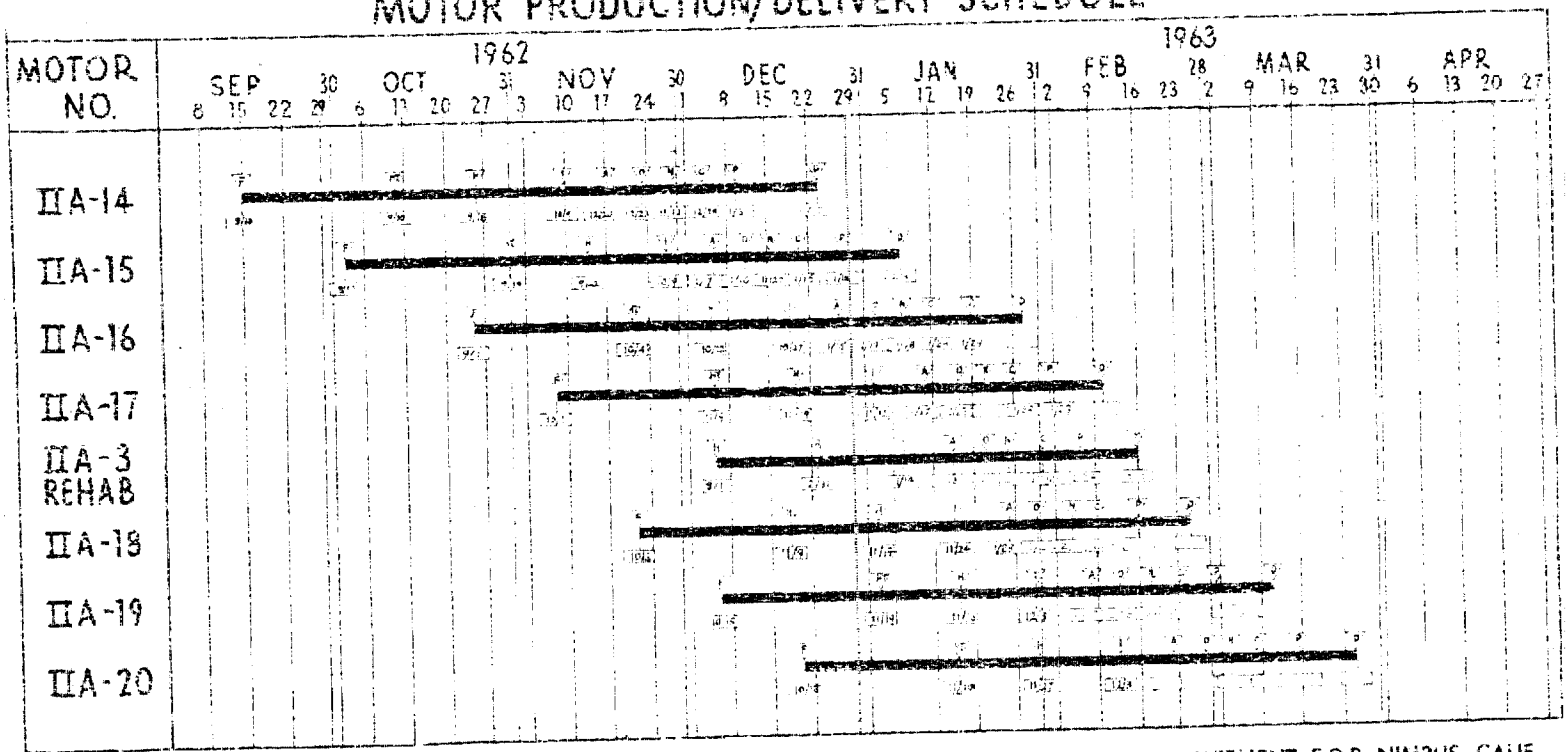
F	START FABRICATION CHAMBER	A	RECEIVE, ABRADE AND LINE	D	FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
HT	HEAT TREAT	O	CAST PROPELLANT	T	TEST FIRE (A.G.C. SACRAMENTO)
H	HYDROTEST	C	CURE PROPELLANT	▽	SCHEDULED TASK COMPLETION DATE
R	REHABILITATE CHAMBER	N	RECEIVE NOZZLE	[DATE]	ACTUAL DATE TASK COMPLETED
I	INSULATE CHAMBER	P	FINAL ASSEMBLY	----	REVIEW DATE

AEROJET GENERAL

3 JAN 63
TP 7415

ALGOL II A

MOTOR PRODUCTION/DELIVERY SCHEDULE



F START FABRICATION CHAMBER
HT HEAT TREAT
H HYDROTEST
R REHABILITATE CHAMBER
I INSULATE CHAMBER
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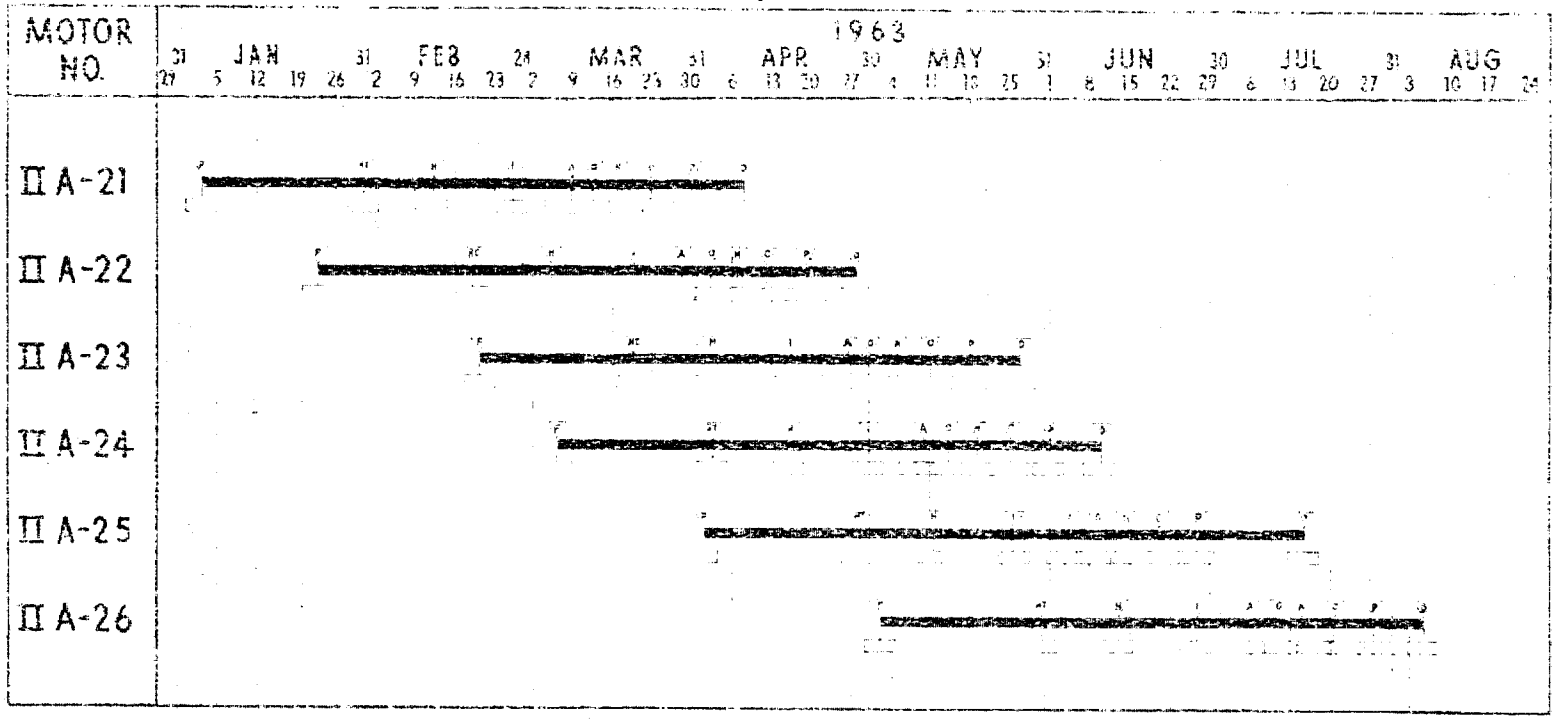
T TEST FIRE (A.G.C. SACRAMENTO)
▽ SCHEDULED TASK COMPLETION DATE
[DATE] ACTUAL DATE TASK COMPLETED
---- REVIEW DATE

ALGOL II A

MOTOR PRODUCTION/DELIVERY SCHEDULE



F START FABRICATION CHAMBER
HT HEAT TREAT
H HYDROTEST
R REHABILITATE CHAMBER
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P FINAL ASSEMBLY
D FINAL INSPECTION AND SHIPMENT, F.O.B. NIMBUS, CALIF.
T TEST FIRE (A.O.C. SACRAMENTO)
▽ SCHEDULED TASK COMPLETION DATE
DATE ACTUAL DATE TASK COMPLETED
---- REVIEW DATE

4 JAN 63
TP 7415

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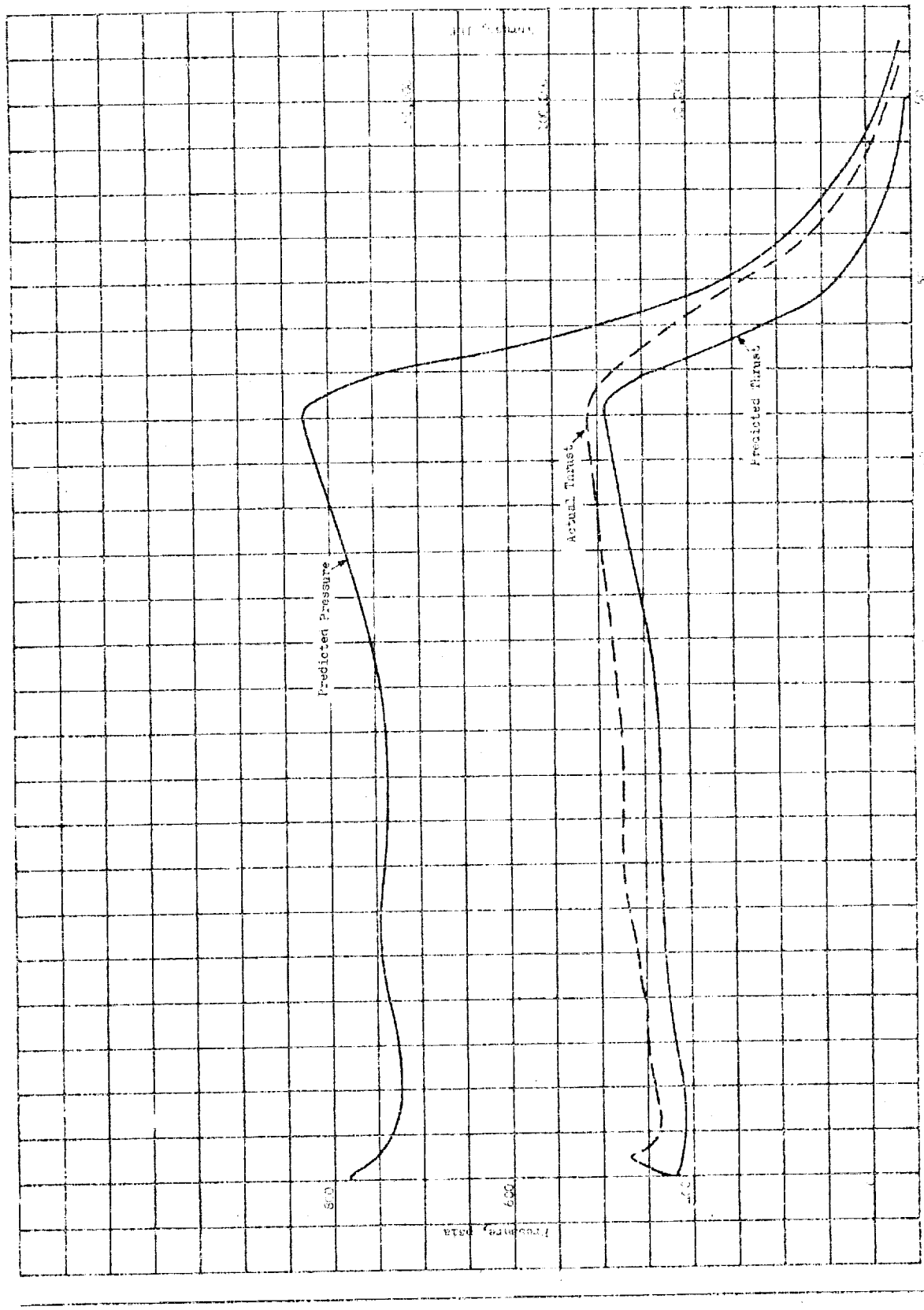
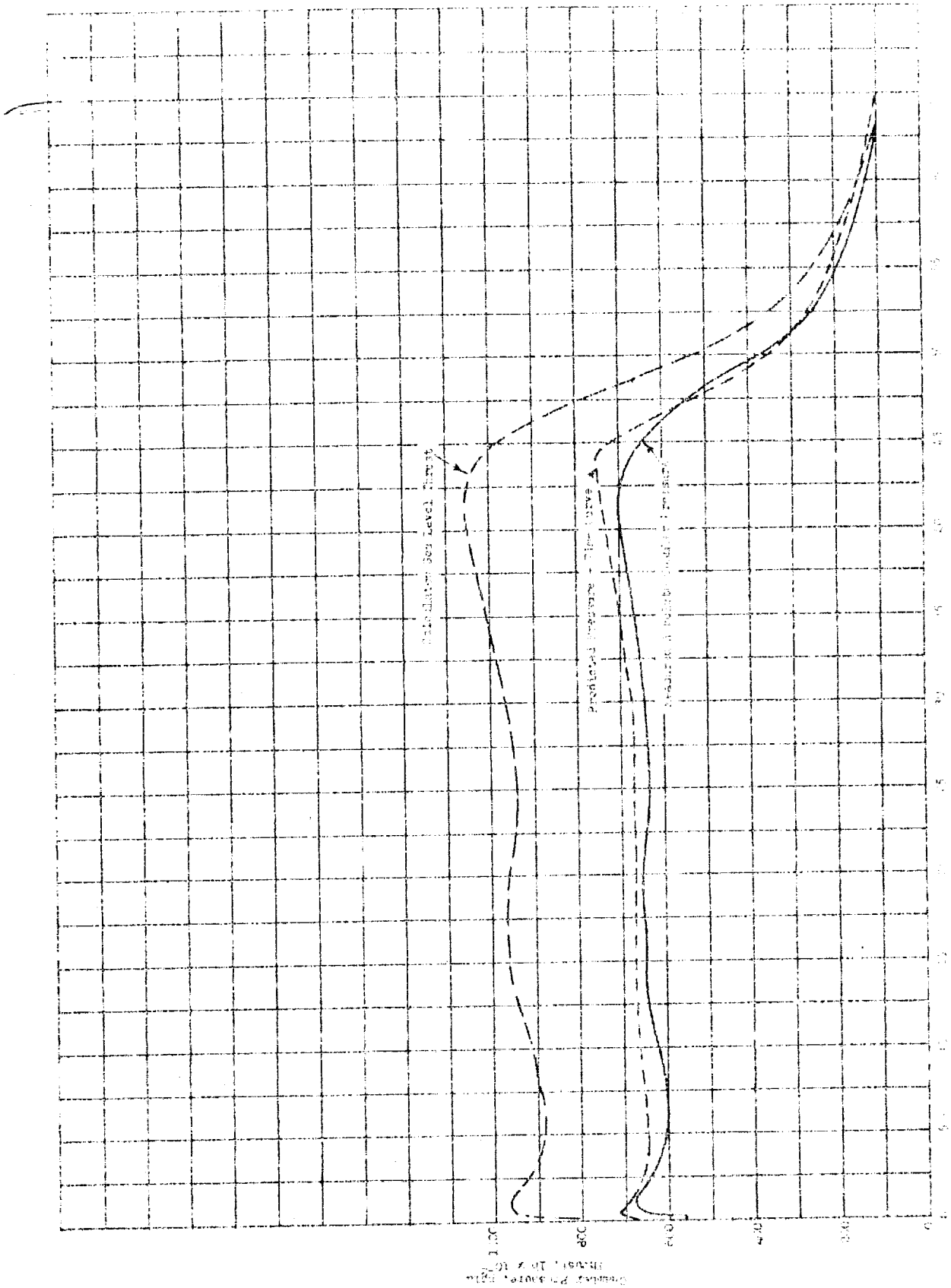
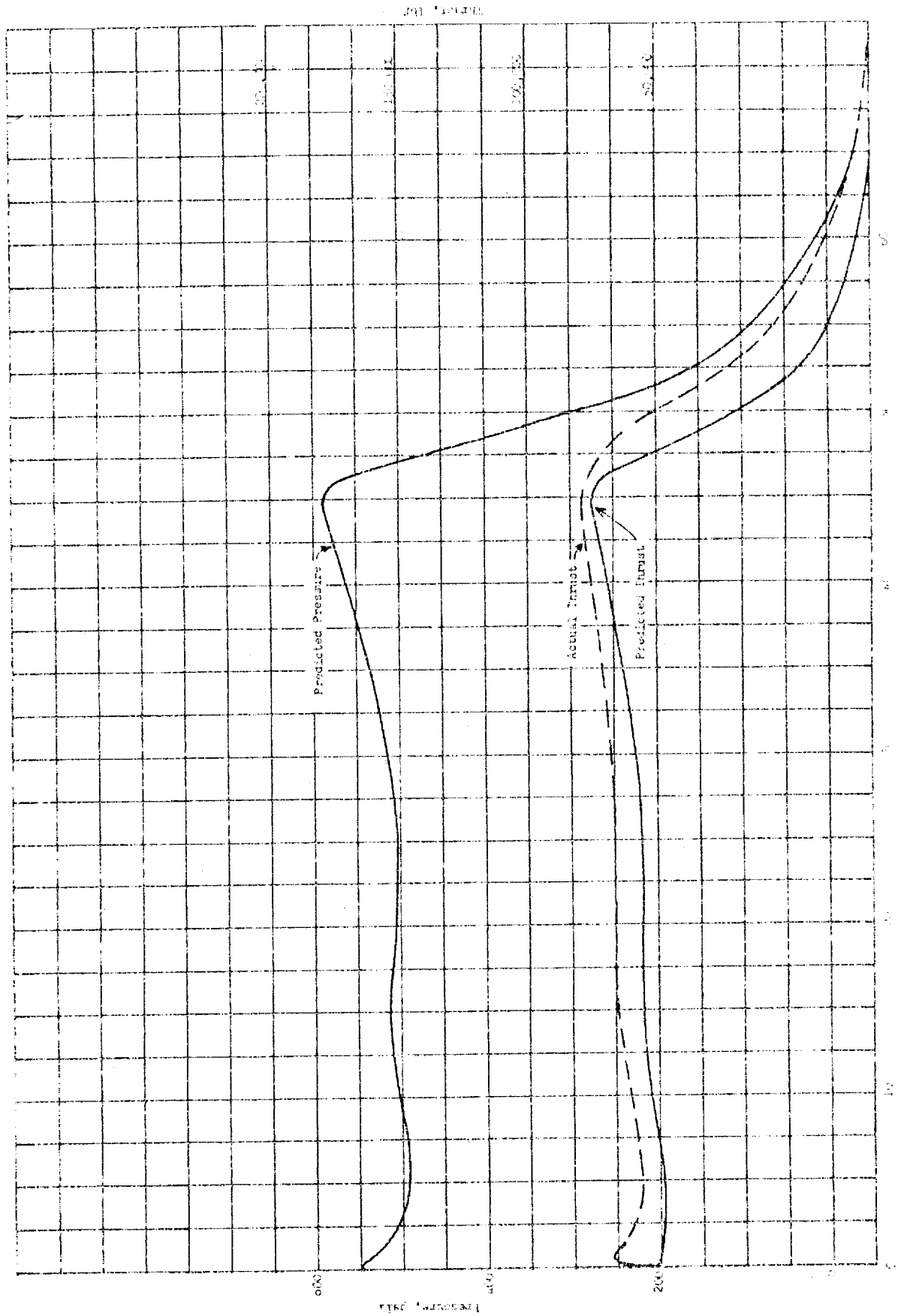


Pressure, Thrust-vs-Time Curves, Predicted and Measured, Algol IIA-4



Pressure Elevation Curves, Predicted and Measured, Algol IIA-3

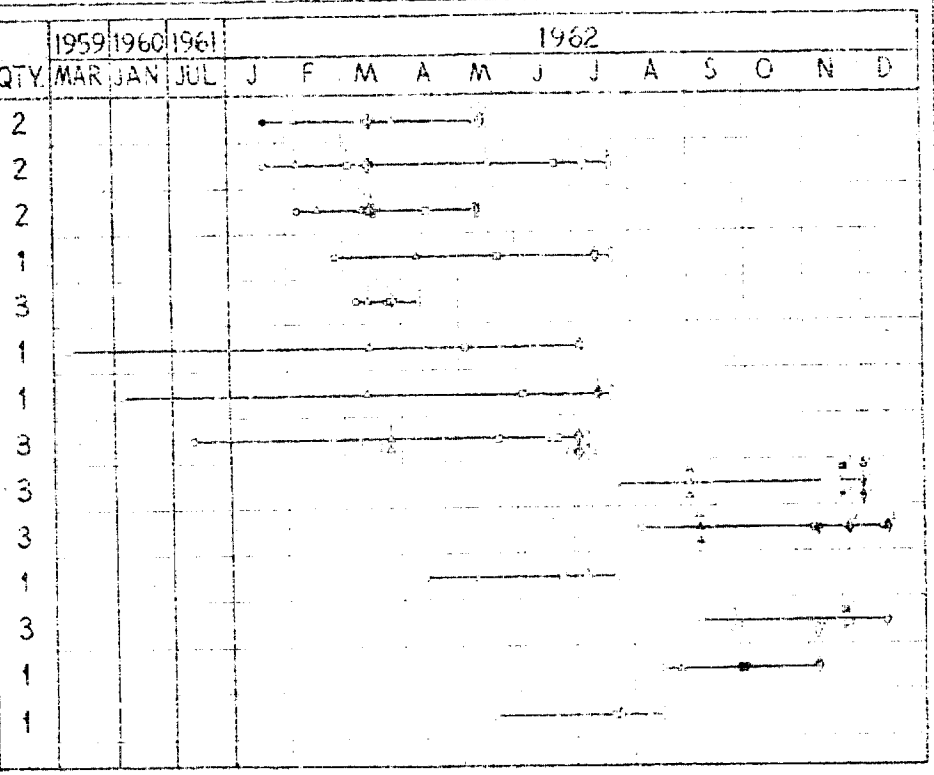


Pressure, Thrust vs. Time Curves, Headquarters and Maintenance, Model HA-6

TOOLING SCHEDULE-ALGOL II A MOTOR

CONTRACT NASI-1330

ITEM NO.	TOOL NO.	DESCRIPTION	QTY.
1.	T-422132	SOFT CORE ASSEMBLY	2
2.	T-422152	CASTING EQUIPMENT	2
3.	T-422163	HANDLING CART CORE	2
4.	T-422188	CURING STAND-TWO MOTORS	1
5.	T-422263	INSTALLATION TOOL-IGNITER	3
6.	T-404262	HORIZONTAL LIFTING BEAM	1
7.	T-420378	BELL EXTENSION	1
8.	T-421737	HANDLING RINGS	3
9.	T-422306	TRANSPORT CART-ALUMINUM CORE	3
10.	T-422305	CORE ASSEMBLY-ALUMINUM	3
11.	E-300044	HORIZONTAL TRAILER	1
12.	T-416147	CORE ASSEMBLY BRACKET	3
13.	T-416148	BREAKAWAY FIXTURE CORE	1
14.	T-422131	PAINT FIXTURE	1



DESIGN COMP DATE — IN FABRICATION — DATE TO BE INSPECTED — DRY RUN — DATE REQUIRED

CHART NO TP 8334
DATE 28 JUN '62

Aerojet-General

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